System dynamics of the energy transition

1. What are transitions?

Societal transitions are defined as non-linear, fundamental changes in a societal (sub-)system. Transitions take decades and can only be truly recognised after the fact. There have been numerous transitions in the past: in mobility, energy, health care, food, culture and public administration. Characteristic for all those processes was the chaotic nature: established views, ways of working and organising come under such pressure that they can no longer be maintained. This leads to a period of instability, often accompanied by crises and chaos, before a new equilibrium is found (Grin et al., 2010).

The study of those historical transitions and the underlying patterns and mechanisms is combined with insights from complex systems theory. This leads to the fascinating insight that a system change marked by fits and starts is an evolutionary fact, and occurs in complex systems in a similar manner, from atomic level to galactic; the evolutionary patterns of variation and selection, build-up and break-down, self-organisation and emergence form the only constant (Rotmans & Loorbach, 2010). For example, think of the phase transition from water to steam if we add heat, or the erratic path of development from child to adolescent to adult. Or transitions in ecosystems that take place when tipping points are passed.

Contrary to natural processes, societal transitions are greatly influenced by human factors like power, behaviour, expectations, strategy, innovation, emotion and interests. Together people develop collective routines, solutions and structures (a 'regime'). By investing money, time and energy we develop infrastructures, markets and institutions which together lead to 'path dependency': the most appealing thing is to continue on the path already embarked upon, which is also in the interest of most parties. This lock-in results in our often being particularly focused on improving the status quo with controlled innovation, which in practice leads to a declining ability to structurally adapt to changing circumstances. A transition (a regime losing its equilibrium) arises when this optimising of the status quo hits a limit, the societal environment changes significantly and alternatives arise (Loorbach et al., 2017).

2. The energy transition

The energy transition is one of the most complex and comprehensive societal transitions: the untenability of a system based on fossil fuels is scientifically undisputed and the transition has commenced a long time ago. In essence, a pattern of change started in the 1970s, which occurrs whether we like it or not. The combination of pressure from the environment, limits to the optimisation of the status quo, and increasing feasibility of alternatives, is slowly but surely upsetting the equilibrium of the centralised fossil energy regime (Markard, 2017). The historical principle is that in this context all kinds of processes occur that are self-accelerating: exponential growth of alternatives, a shifting societal consensus, the strategy overhaul on the part of companies (Loorbach, 2014).

In practice we see that actors within the regime think and work on the basis of the gradual pace of change and historical stability offered by the regime. From a scientific perspective, however, this starting point is the least likely: the only future that is not possible or desirable, is business as usual. The effects of climate change are now palpable, making this a problem also for the short term. The political and societal unrest are signals of instability which, combined with the willingness and need

to intervene, can lead to rapid transitions. When the awareness necessary for transitions, the sense of urgency and perspective for action combine, transition space opens: things that were deemed self-evident disappear, predictability dissolves, resulting in great unrest. Knowledge and predictions based on the past are of little value, in particular when these predictions are based on reasoning rooted in the stability and linearity from the past.

The political, societal and financial context shifts rapidly in this chaos phase of transition. For example, the rise of global protest movements calling for the phasing out and divestment of fossil fuels. In the meantime, large investors, like pension fund ABP, are heeding this call[1]. In addition, we see global policy initiatives like the Beyond Oil and Gas Alliance, in which countries agree to phase out production and use of oil and gas.[2] We also see that climate policy is being tightened, recently even in the US[3], the second largest emitter in the world.

The judgment in the Shell climate case can also be viewed in this light of turbulent system dynamics.[4] It underlines the prediction which was made in the transition perspective in the Shell climate case at first instance,[5] i.e. that the judgment in the Shell climate case would have a wider impact, but particularly that the indirect (system) effects thereof would be at least as big as the direct (market) effects. For example, the judgment has contributed to an increased (financial) risk profile for the fossil industry, a risk that the oil and gas companies themselves also acknowledge.[6] In addition, it was a wake-up call for numerous other companies domestically and abroad and in a wide range of industries.[7] The judgment is also an inspiration for a growing number of lawsuits in which governments and companies are being summoned to take more action to combat dangerous climate change, thereby protecting human rights (Heffron, 2021; Setzer & Higham, 2022).

The fossil industry will be confronted with break-down and phase out no matter what, possibly enforced by societal pressure and external shocks like the war in Ukraine. The pattern is one of unpredictability, uncontrollability and self-reinforcing processes: the shifts in markets force companies to reposition, so that historical sector structures become unstable and companies are forced to reposition again; in the event the desired changes do not occur, governments must ultimately take fundamental actions, so that institutional structures become more unstable and large-scale policy modification is necessary; citizens orient themselves on other values, so that new behaviour patterns arise that others will follow, causing a change in societal norms.

On top of that, these changes within the market, government and society also reinforce each other. Examples are the shift in eating patterns to more plant-based proteins, which has created a new market for meat alternatives, which in turn leads to new regulations and other discussions about agricultural policy, which together create more attention and persuade consumers to move toward

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1 See: NOS (2021) https://nos.nl/artikel/2403152-grootste-pensioenfonds-abp-stopt-met-beleggen-in-olie-en- gasbedrijven

2 See: https://beyondoilandgasalliance.com/

3 See, e.g.: Financial Times (2022) https://www.ft.com/content/2e2855c5-3dfd-4b41-b53a-aeff4671e992 4

4 See also: IPCC AR6 WGIII section 13.4.2: https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_Chapter13.pdf

5 See the statement of Prof. Dr. Ir. Jan Rotmans, submitted as Exhibit 338

6 See, e.g.: Shell Annual Report 2021, p. 23 and p. 28. https://reports.shell.com/annual-report/2021/_scripts/download.php?file=shell-annual-report-2021.pdf&id=1273; BP Annual Report 2021, p. 59. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/investors/bp-annual-report-and-form-20f-2021.pdf and ExxonMobil Annual Report 2021, pp. 3 and 4 https://corporate.exxonmobil.com/-/media/Global/Files/investor-relations/annual-meeting-materials/annual-report-summaries/2021-Annual-Report.pdf

7 See, e.g.: Trouw (2021) https://www.trouw.nl/economie/bernard-wientjes-ik-heb-alle-grote-chemiebedrijven- wel-aan-de-lijn-gehad-over-de-shell-zaak~bdde93ef/; Financial Times (2021) https://www.ft.com/content/55395ba1- 7a14-4059-9853-1572f49c57aa

plant-based foods (Tziva et al. 2020).[8] Or the transition in mobility, in which more and more city dwellers without their own car make use of all kinds of available forms of mobility, which is played into by shared mobility providers, and municipal governments alter the layout of the public space to give more space to green, health and sharing (Griffiths et al., 2021).[9]

3. Shell as system player in the energy transition

Shell is what is known as a 'keystone actor' or system player in the energy sector. This metaphor is used in science to refer to actors around which an entire ecosystem of parties has developed (Österblom et al., 2015; Hilleman et al., 2020). System players are the pillars of societal systems and they often offer predictability and stability. In transition dynamics, system players are important transition points: if they make a fundamental change in course or position, the whole system will shift.

We define a system as a value chain and an actor as a company, and a system player as a company that plays a critical role in the entire value chain. A critical role means that it can influence or disrupt the entire value chain or make it change course. This can be from the inside, by a regime system player, or from the outside, in which case we speak of a niche system player or disruptor. The critical role can be based on the power position, with regard to position, size, investment level, innovation potential and earnings model. Tesla, for example, started as a niche system player, with a totally new concept for an electric car, more like a computer on wheels then a car as such. Tesla did not want to electrify the car industry as such, but offer a solution for making energy sustainable and solving the underlying climate problem. Through this new philosophy and this new business model, Tesla became a disruptor because it influenced the entire car industry and pushed it in a new direction, i.e. that of electrification. In the meantime Tesla has grown into the most valuable car manufacturer in the world and virtually all big car manufacturers are shifting to electric cars. Disruptors or niche system players often come from outside the sector, in part because they see possibilities and solutions which are overlooked within the sector. They are, as it were, trespassers in the status quo.

Shell is a regime system player, that has its tentacles in the whole energy value chain, from production, distribution, processing to sales. Shell has such a big investment budget, has so much expertise and such a network, that it can change the direction of the entire energy system. A first step can be seen in the area of green hydrogen, which Shell is focusing on in the Netherlands and for which it has managed to mobilise a wide coalition.[10] Shell will build an electrolyser of 200 MW in Rotterdam in 2025, which will be the biggest green hydrogen factory in Europe. When it is finished, the electrolyser will provide 10% of the hydrogen requirements of the Shell refinery in Pernis.[11] The other 90% will continue to come from fossil natural gas. Shell's ambitions in this area will entail that other companies and the Dutch government will follow and start investing in green hydrogen more quickly.[12]
A lot of wind energy is necessary for green hydrogen production, which means that in the coming decades 10-15 large wind farms will have to be built in the North Sea. The green hydrogen can then

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8 See, e.g.: https://www.insiderintelligence.com/content/while-plant-based-food-sales-growing-industry-faces- challenges

9 See, e.g.: https://www.kimnet.nl/actueel/nieuws/2022/02/22/verschillen-in-autoafhankelijkheid-tussen-stad- en-land-groeien and https://www.verkeersnet.nl/mobiliteitsmanagement/39587/waarom-gaan-autos-verdwijnen-uit-de- steden/

10 See: FTM (2022) https://www.ftm.nl/artikelen/shell-pusht-waterstof-in-groningen?share=slNKt71vSaoZcVb1yJABlhwkymLi7S9rm%2FXepHukGIs9msdDDKPLXfmISDcONmY%3D en https://opwegmetwaterstof.nl/

11 See: NOS (2022) https://nos.nl/artikel/2435486-shell-bouwt-groene-waterstoffabriek-in-rotterdam

12 See: Trouw (2022) https://www.trouw.nl/duurzaamheid-natuur/shell-zet-een-eerste-bescheiden-stap-richting-de-waterstofeconomie~b98a2708/ en https://www.north2.eu/en/

be transported to the country in gas pipes. Shell's investment decisions therefore also have significant consequences for the wind industry. This example shows that Shell has influence in the whole value chain and can influence the wider system, which are by definition the characteristics of a system player.

It is striking that Shell does not play upon its position as system player far more explicitly to accelerate the energy transition and limit dangerous climate change as much as possible. Because Shell's investments in sustainability (like green hydrogen) are still very modest in proportion to its investments in fossil fuels.

We therefore do not yet see any trace of an actual transition strategy of build-up and break-down. Indeed, Shell's double agenda is becoming ever clearer: green hydrogen is going to be used in Shell's oil refineries, which will continue producing oil products and for which 'grey hydrogen' (hydrogen produced on the basis of fossil fuels) will be used for a long time to come. Shell is primarily concerned with making its production of fossil fuels partly sustainable and not with phasing out that production. The green ambitions are therefore, for the time being, primarily being used to protect the fossil core of its business model.

In short, Shell is the ultimate (regime) system player and could use that position to make the entire energy system sustainable more quickly. However, Shell is not doing that: Shell limits its role to looking for substitutes for oil and gas (particularly via green hydrogen and biofuels) in order to continue producing and selling fossil products for a long time. The strategy is therefore purely geared to Shell's own financial profit with disastrous consequences for the habitability of the planet.

4. The shifting of Shell's investment flows is taking too long

Article 2 of the Paris Climate Agreement states that shifting investment flows is crucial for limiting dangerous climate change.[13] The shifting of investment flows within Shell is not exactly moving at a high speed. Our estimate is that at most 5% (1.2 billion $) of Shell's total investment budget (in 2021 some 25 billion $) goes to sustainable energy. Shell itself says that it is approx. 12%, 2.4 billion $, but this number also encompasses investments in 'energy solutions', including marketing, trading and selling of fossil natural gas[14], so the number is rather 'padded out'. However, the investments in 'Upstream', including exploration and pumping up oil, will be increased from 6 to 8 billion $ in 2022. A thorough analysis of the Shell investment portfolio by the Australian Global Climate Insights (GCI) thus comes to the conclusion that in 2030 an increase of 3% of Shell's absolute CO_2 emissions can be expected, instead of a decrease.[15] This investment behaviour is at odds with the transition that is necessary within Shell to achieve the 45% CO_2 reduction by 2030 as ordered by the court.

In transition terms, this is due to the structure, culture and practices within Shell. A review of the Shell organisation shows that the structure of Shell is hierarchical and bureaucratic, characterised by top-down steering and slow decision making from below. Own initiative is a rarity, permission from higher up is always required first. In addition, Shell is big, slow and complex, with a silo structure, which makes rapid decision making difficult. The culture is formal and cautious, with a certain fear of change, inward facing and geared to certainty and stability. This culture, that inhibits real change, is maintained by the older generation of directors within Shell who by and large keep running the organisation as they have done for the past decades.

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13 See: https://unfccc.int/sites/default/files/english_paris_agreement.pdf

14 See: Shell Annual Report 2021, p. 49, https://reports.shell.com/annual-report/2021/_assets/downloads/shell-annual-report-2021.pdf

15 See: https://www.accr.org.au/downloads/2022_09_gci_shell_forecast_update.pdf

In short, the conclusion is that Shell is not a flexible organisation, nor does it have a pioneer culture, even though it claims to be a frontrunner in the energy transition. This explains, inter alia, why reducing the investments in fossil fuels just do not get off the ground and the expansion of investments in renewable energy is moving so slowly at Shell.

5. Stagnation of Shell and the lock-in effect

As a system player Shell contributes to a fossil lock-in: because it keeps investing in fossil energy, other big players in the energy field will continue to do so as well and the fossil fuel infrastructure will remain in place for longer. The underlying reason for this is as follows: Shell is focused on immediate high returns, which keeps leading it back to fossil fuels as a dominant investment with a high and direct return on investment. This maintains the high fossil fuel production and the dominant fossil infrastructure. This results in ever-increasing transition costs (switching to other, sustainable forms of energy, costs of investments in people, knowledge, networks, technology and infrastructure), further complicating a transition which is already moving too slowly. Consequently significant political and economic interests remain to maintain the fossil fueled business model for as long as possible. Due to the knock-on effects of the fossil lock-in on other players in the system, it will be virtually impossible to achieve the climate goals.

The converse reasoning applies just as well, however: if Shell were to be aiming at long-term returns, it would invest more money, more quickly in renewable energy, so that the fossil fuel production can decrease more quickly, so that the fossil fuel infrastructure is phased out more quickly, so that the transition costs decrease, so that the political and economic interests in continuing to defend the fossil business model will decrease, so that the climate goals remain within reach.

The conclusion is that Shell, as a system player, has a significant responsibility for the stagnation of the energy transition and failure to achieve the climate goals. Because the internal transition within Shell is faltering, shifting the investment flows to renewable energy is not occurring sufficiently quickly and significantly. Due to the impact of Shell on other players, they are following that same route, so that the energy transition is encountering significant delays and the current sizeable fossil fuel infrastructure may be maintained for decades.

Shell only takes on a certain value chain responsibility for green hydrogen, based on an obvious self-interest, and this shows that other big actors in the field follow Shell's example (in terms of production, distribution and processing of green hydrogen) and this drives activity in the entire hydrogen chain. Unfortunately, these investments in green hydrogen are just a drop in the ocean. Just think if Shell were to really focus on renewable energy on a large scale (wind, sun, green hydrogen, biomass, geothermal, aquathermal, etc.), this would mean an enormous acceleration of the energy transition.

In short, the energy transition can only accelerate when system players like Shell undergo an internal transition, whereby the organisation, culture and practices are geared to the phasing out of fossil fuels and the expansion of sustainability and, in addition to financial impact, are geared towards societal impact. A court order to substantially reduce CO_2 emissions would help in this respect and would also give the wider energy market a push in the right direction.

6. Steering and transition

Practice shows that emissions reduction goals which both governments and companies set for themselves up to now have not been or have barely been achieved, particularly because in practice

they are translated into improvements of the status quo, without adapting the underlying structures.[16] By definition there is a limit on how optimally or efficiently (or 'climate friendly') fossil fuel technology can be made: a fossil car or refinery will, at the end of the day, always have emissions. Although reductions can yet be achieved by companies like Shell within the status quo (from scope 1 to 3) by becoming more efficient, capturing emissions and switching with regard to certain components to alternative sustainable sources or energy carriers like hydrogen. However, in order to achieve true climate neutrality, the underlying structure will have to fundamentally change: on the basis of other technologies, business models, expertise, raw materials, new joint ventures and within a highly adapted institutional framework.

If the inevitability of the energy transition were really the starting point for Shell, then it requires a different strategy and form of steering. A strategy that is not based on improving the status quo, but is based on 'learning by doing' geared towards desired alternative futures after the transition (Loorbach, 2010; Loorbach & Wijsman, 2013). From the phasing out of that which is not sustainable or tenable and the incremental build-up of new systems. This is a challenge for both established companies and governments: interests are deeply rooted in the status quo and the entire working method is geared to the maintaining thereof. In other words: regular forms of policy and management often maintain the status quo, which in the longer term will in fact lead to the path dependency which in turn leads to transition pressure.

Up to now Shell has come up with promises and ambitions, but has not taken serious action to shape its own transition in terms of the core of the business: extracting and selling fossil fuels. From the historical logic and the own internal regime, Shell is primarily geared to improving what exists, partly due to the belief in technological innovation, but also from the conviction that policy can be influenced in a sense favourable to them and that those alternatives and societal pressure will not be a big problem. In that sense Shell did not take the message of transition science very seriously: the message that transition dynamics happen to us precisely because we resist the need for change or deny or ignore it, and that by delaying that which is unavoidable, the dynamics will be more severe and the chance of undesirable outcomes will be greater.

A very topical parallel with the energy transition is the nitrogen crisis. Here too science has been clear for decades on the consequences of excessive nitrogen deposits. In response, the focus was primarily on technological innovation, efficiency and improvement of the existing system, so that the underlying structure of the agricultural industrial complex remained intact. In combination with this, political decision makers kept kicking the can down the road: every time there seemed to be consensus to intervene, political, economic and social interests came into play, resulting in so much resistance, that postponing and watering down was chosen instead. Now that the agricultural system has truly hit the ecological limits and intervention has become unavoidable from a legal perspective, political decision makers can no longer avoid structural changes. The transition pressure is mounting to a maximum, with unrest, chaos and crisis inside and outside of the sector. This degree of societal crisis could have been prevented if political decision makers, farmers (organisations), agricultural industry and banks had taken the evident need for structural change seriously at an earlier stage and had anticipated and acted on this.

7. Expectation for the future

The transition dynamics which our society has to deal with have been predicted in a general sense, and it is also fairly clear how this will play out in the coming years: increasing chaos, crises and

16 See, e.g.: Berenschot (2022) https://www.berenschot.nl/media/aqsbflq2/berenschotpublicatie_regionale- ontwikkeling-broeikasgasuitstoot-1990-2020-2030.pdf

conflicts, but equally there will be breakthroughs, shifts in politics, law and society and new forms of stability in market and policy. System players like Shell are crucial in this context. In transition dynamics these system players can be important transition points: if they fundamentally change course, forced or otherwise, the whole system shifts.

This transition dynamic is global: the financial and societal risks relating to fossil fuels lead to increasing concerns, which cause these risks to increase again. In the short term, the need for (fossil) energy is still large enough for companies like Shell not to have an acute problem. But in the mid-long term transitions in, inter alia, mobility, industry and construction in combination with leaps forward in sustainable energy generation will lead to a significant reduction in the need for fossil energy.

Objecting to the court's judgment can buy Shell time, but it cannot avoid the inevitable transition. Indeed, the judgment can in fact help Shell to embark upon its own transition: it will have to start thinking past the efficiency and innovation of the status quo. What will be an undeniable consequence, in part based on the effects of the judgment at first instance, is that the societal transition already embarked upon will accelerate further.

When embracing fundamental change, Shell, as a system player, will take along the entire ecosystem of companies and organisations with which it is affiliated, including policy and consumers in this transition. The shifts in policy and society will in their turn have a reinforcing effect on the transition of Shell itself.

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CV´s Prof. Dr. Ir. Jan Rotmans and Prof. Dr. Derk Loorbach

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He is an international authority in the area of transitions & sustainability, and advises international and national public bodies and companies, such as the UN, EU, OECD, the Dutch government and multinationals, including Shell and IKEA. He has managed a number of prestigious global and European research projects. He developed the first integral climate model in the world, IMAGE, which is still being developed after 35 years and is intensively used in the international climate negotiations. He was involved in the founding of the UN climate panel IPCC within which he was active for years.

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At the same time, he is involved in many transition processes in administrative and business circles, the public domain and in science. For example, he has worked for the World Bank, the United Nations Convention on Biological Diversity and the Rotterdam Climate Initiative. He is also a member of the national Energy Transition advisory council of the Ministry of Economic Affairs and Climate Policy. In addition, he is currently the academic lead of the Design Impact Transition platform of Erasmus University and curator of the tenth Architecture Biennial in Rotterdam on transitions.

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